Claims

1. A diaphragm valve comprising:

a valve body defining a valve passage having an inlet and an outlet;

a diaphragm having first and second sides and positioned such that the first side is proximal to the valve passage;

an actuator operably coupled to the first side of the diaphragm for applying an actuation force to the diaphragm, the diaphragm operable in response to the applied actuation force to transition between a closed position blocking the valve passage and an open position wherein the valve passage is at least partially open; and

a heating body thermally contacting the valve body and extending proximal to the second side of the diaphragm, thereby forming a thermally conductive pathway from the valve body toward the diaphragm that facilitates maintaining an operating temperature at the diaphragm.

2. In combination with a diaphragm valve according to claim 1, a heater in thermal association with the valve body, the heater adapted to generate heat which is conducted through the valve body and the heating body to thereby prevent a medium in the valve passage from condensing or freezing in the valve passage.

3. A diaphragm valve according to claim 1 wherein the heating body comprises a material selected from the group consisting of aluminum, stainless steel, titanium and copper.

4. A diaphragm valve according to claim 1 wherein the heating body is interposed between the diaphragm and the actuator, the heating body includes a central opening in alignment with the diaphragm and the actuator, and further comprising a plunger extending through the central opening and operably coupling the actuator to the diaphragm.

5. A diaphragm valve according to claim 4 wherein the plunger includes a section of reduced cross sectional area located between the diaphragm and the actuator to thereby reduce thermal conduction through the plunger and to the actuator.

6. A diaphragm valve according to claim 5 wherein the section of reduced cross sectional area includes a hollow region of the plunger.

7. A diaphragm valve according to claim 4 wherein the plunger includes a first end section engaged by the actuator mechanism, a second end section operably

coupled to the diaphragm and being formed of a first material, and a central section between the first and second end sections, the central section being formed of a second material having a substantially lower thermal conductivity than the first material.

8. A diaphragm valve according to claim 1 wherein the actuator includes a solenoid.

9. A diaphragm valve according to claim 1 further comprising a thermally resistive member interposed between the valve passage and the actuator for attenuating heat transfer between the valve passage and the actuator.

10. A diaphragm valve according to claim 9 wherein the thermally resistive member comprises a plunger having a first end engaged by the actuator, a second end operably coupled to the diaphragm, and a hollow region between the second end and the actuator.

11. A diaphragm valve according to claim 9 wherein the thermally resistive member includes a plunger having a first end section engaged by the actuator mechanism, a second end section operably coupled to the diaphragm and being formed of a first material, and a central section between the first and second end sections, the central section being formed of a second material having a substantially lower thermal conductivity than the first material.

12. A diaphragm valve according to claim 9 further comprising a valve stem supporting the actuator and wherein the thermally resistive member comprises an insulating pedestal separating the valve stem from the heating body.

13. A diaphragm valve according to claim 12 further comprising an elastomeric or plastic seal interposed between the valve stem and the heating body.

14. A diaphragm valve according to claim 12 further comprising a fastener coupling the valve stem to the heating body and a thermal insulator positioned between the fastener and the valve stem.

15. A diaphragm valve according to claim 1 wherein the actuator comprises a solenoid coil and a plunger having a first end extending within the solenoid coil and a second end operably coupled to the diaphragm, the plunger being driven in response to energizing of the solenoid coil to thereby transition the diaphragm between the open and closed positions.

16. A diaphragm valve according to claim 15 further comprising a spring operably engaged with the plunger for biasing the diaphragm toward one of the open and closed positions.

17. A diaphragm valve according to claim 16 wherein:

the spring biases the diaphragm toward the closed position; and

the plunger is driven to oppose the spring and move the diaphragm to the open position in response to energizing of the solenoid coil.

18. A diaphragm valve according to claim 15 further comprising a thermally insulating slide bushing interposed between the plunger and the actuator.

19. A diaphragm valve according to claim 1 wherein the actuator includes a movable plunger, a stop positioned to limit the movement of the plunger, and a thermally insulating blocking member interposed between the plunger and the stop.

20. A diaphragm valve according to claim 1 further comprising a valve seat positioned in the valve passage opposite the diaphragm, the valve seat having a seating surface facing the diaphragm and against which the a substantial portion of the first side of the diaphragm is pressed in response to the applied actuation force to thereby block the valve passage, the seating surface being characterized by an absence of sharp features to thereby prevent shearing of the diaphragm when the first side of the diaphragm is pressed against the valve seat.

21. A diaphragm valve according to claim 1 further comprising a valve seat positioned in the valve passage opposite the diaphragm, the valve seat having a seating surface facing the diaphragm and against which the first side of the diaphragm is pressed in response to the applied actuation force to thereby block the valve passage, the seating surface extending radially from the inlet for contacting a substantial portion of the diaphragm when the first side of the diaphragm is pressed against the valve seat, to thereby improve heat transfer from the valve seat to the diaphragm.

22. A diaphragm valve according to claim 1 wherein the diaphragm is comprised of a plastic material.

23. A diaphragm valve according to claim 1 wherein the diaphragm is comprised of an elastomeric material.

24. A diaphragm valve according to claim 1 wherein the first side of the diaphragm includes a protective coating selected from the group consisting of an oxide, a nitride, a carbide, and mixtures thereof.

25. A diaphragm valve according to claim 1 further comprising:

an enclosed space adjacent the second side of the diaphragm;

a venting passage in communication with the enclosed space; and

a pump operably coupled to the venting passage.

26. A precursor material delivery system including a diaphragm valve according to claim 1.

27. A precursor material delivery system including a diaphragm valve and heater according to claim 2.

28. A precursor material delivery system including a diaphragm valve according to claim 9.

29. An ALD reactor including a diaphragm valve according to claim 25.

30. An ALD reactor including a precursor material delivery system according to claim 26.

31. An ALD reactor including a precursor material delivery system according to claim 27.

32. An ALD reactor including a precursor material delivery system according to claim 28.

33. A diaphragm valve comprising:

a body means defining a valve passage having an inlet and an outlet;

a diaphragm having first and second sides and positioned such that the first side is proximal to the valve passage;

means for actuating the diaphragm to transition the diaphragm between a closed position blocking the valve passage and an open position wherein the valve passage is at least partially open; and

means for conducting heat from the body means toward the diaphragm to facilitate maintaining an operating temperature at the diaphragm.

34. In combination with a diaphragm valve according to claim 33, means for heating the body means to thereby prevent a medium in the valve passage from condensing or freezing in the valve passage.

35. A diaphragm valve according to claim 33 wherein the means for actuating comprises a solenoid.

36. A diaphragm valve according to claim 33 further comprising means for attenuating heat transfer between the valve passage and the means for actuating.

37. A diaphragm valve according to claim 36 wherein the means for attenuating heat transfer comprises an insulating pedestal interposed between the body means and the means for actuating.

38. A diaphragm valve according to claim 36 wherein the means for attenuating heat transfer comprises a plunger having a section of reduced thermal conductivity.

39. A diaphragm valve according to claim 33 wherein the means for actuating includes a solenoid.

40. A diaphragm valve according to claim 33 further comprising means defining an enclosed space adjacent the second side of the diaphragm.

41. In combination with a diaphragm valve according to claim 40, means for drawing a vacuum in the enclosed space.

42. A diaphragm valve according to claim 33 further comprising means for reducing a fluid pressure on the second side of the diaphragm.

43. A precursor material delivery system including a diaphragm valve according to claim 33.

44. A precursor material delivery system including a diaphragm valve according to claim 34.

45. A precursor material delivery system including a diaphragm valve according to claim 36.

46. An ALD reactor including a diaphragm valve according to claim 33.

47. An ALD reactor including a diaphragm valve according to claim 34.

48. An ALD reactor including a diaphragm valve according to claim 36.

49. An ALD reactor including a diaphragm valve and means for drawing a vacuum according to claim 41.

50. An ALD reactor including a diaphragm valve and means for reducing a fluid pressure according to claim 42.